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ABSTRACT

Reported are three studies which have been completed since the inception of a collaboration between the Inglewood Schools and UICSM. These include a comparison by a matched-pairs design, a total group comparison in which covariance analysis provided statistical control, and an item analysis of the tests which obtained difficulty indices for the UICSM experimental group and the comparison group on each item. Forty matched-pairs of UICSM and non-UICSM students were formed on three variables and the two groups were compared on the Cooperative Elementary Algebra and Cooperative Math, Algebra 1, tests. The results showed significantly higher achievement by the UICSM students on both the Cooperative Elementary Algebra and Cooperative Math examinations. (RP)

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Abstract

Three statistical analyses were performed on test score data for students from Inglewood, California: (1) a matched pairs design (2) a covariance analysis, and (3) an item analysis in terms of difficulty indices. Forty matched-pairs of UICSM and non-UICSM students were formed on three variables and the two groups were compared on the Cooperative Elementary Algebra and Coop Math, Algebra 1, tests. No significant differences were found in test score means. The covariance analyses resulted in statistical adjustments on six and five variables for junior and senior high school groups of students respectively. The same two criterion variables were used for both the junior high and senior high groups and significant differences were found in both groups when adjustment was not made for teacher ratings by school principals. The results showed significantly higher achievement by the UICSM students on both the Coop Elementary Algebra and Coop Math examinations. The item analysis of the two criterion tests showed significantly better achievement by UICSM students on ten items from the two tests; while non-UICSM students excelled in four items at a significant level.

The studies described in this report were initiated by the research section of UICSM at the request of Dr. Quentin R. Bryan, Coordinator of Special Projects for the Inglewood Unified School District. These studies consisted of tests administered by Inglewood teachers but selected and scheduled in close collaboration with the senior author, who visited the school system and maintained close contact with Dr. Bryan and his staff. This request for help offered an opportunity for the project to obtain a "reading" on the level of achievement in a school system that had newly adopted the UICSM curriculum.

The Inglewood Unified School District includes two junior high schools (7-8) and two senior high schools (9-12). Five classes of superior 8th grade students, one class of superior 9th grade students, and one class of "randomly" selected 9th grade students used UICSM materials as their course of study. Median intelligence scores for students in this district have consistently been above the national norm. Placements in the junior high school experimental

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*The authors wish especially to acknowledge the assistance of Judith Boyle who performed many of the calculations.

sections were made on the basis of the California Algebra Aptitude Test (CAA), administered in the spring of 1962, and the high school students were selected on the basis of past performance in mathematics. A total of 209 pupils were enrolled in these seven UICSM sections. Five of these sections (those at the 8th grade level) had studied only the first ten pages in Unit 4, at the time the two Coop algebra tests were administered. The other two experimental sections (9th grade) had completed Unit 4. This means that approximately 150 out of the 209 UICSM students in these sections completed only about three-fourths of the First Course at the time of testing.

Three studies have been completed since the inception of this collaboration between the Inglewood schools and UICSM. These include a comparison by a matched-pairs design, a total group comparison in which covariance analysis provided statistical control, and an item analysis of the tests which obtained difficulty indices for the UICSM experimental (E) group and the comparison (C) group on each item.

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A Comparison of Matched Groups

Forty first-year UICSM students (9th grade) were matched with forty non-UICSM 9th-grade students of first year algebra on three variables: (1) CTMM-L, (2) CTMM-NL,[1] and (3) STEP-Math.[2] The degree of matching may be noted in Table 1. At the end of the year, scores on the Cooperative Elementary Algebra Test, Form T(1950), and the Cooperative Mathematics Test, Algebra I, Form A(1962) were obtained for thirty-two of the forty pairs. The use of standardized tests of this character as criterion variables for comparison of achievements made by the two groups were justified by the fact that the UICSM course has the same general goals as traditional algebra.

[1]CTMM: California Test of Mental Maturity (1957); (L, language; NL, non-language) published by the California Test Bureau.

[2]STEP-Math: Sequential Tests of Educational Progress — Mathematics (1957) published by the Cooperative Test Division, Educational Testing Service.

Table 1. Mean differences on three control variables and two criterion variables for matched pairs of UICSM and comparison students.

	Control Variables			Criterion variables	
	CTMM-L	CTMM-NL	STEP Math	Coop Algebra	Coop Math
Mean difference (E - C) †	0	.45	.50	2.06	-1.03
S. E. of mean difference (E - C)	.80	.46	.32	1.83	1.04
t	0	.69	1.56	1.13	-0.99
No. of pairs	40	40	40	32*	32*

*Criterion scores were not available for all 40 pairs of students.

† Hence, positive differences are in favor of UICSM.

As shown in Table 1, the results were rather equivocal and in a strange direction. The UICSM group did somewhat better than its counterpart on the Coop Algebra test, but the difference was not statistically significant as determined by a one-tailed t-test at the 5% level. The comparison group on the other hand had a non-significantly higher mean on the Coop Math, Algebra I, test. We are not entitled to draw any conclusions. However, we should note that the opposite finding might well have been expected, since the Coop Algebra test is heavy on applications which are less strongly emphasized in UICSM first course than in traditional algebra courses. On the other hand the new Coop Math, Algebra I, test contains a number of "modern mathematics" items, e.g., 29, 33, 35, 36, so one might have expected UICSM students to perform better on it.

* * *

A comparison of all UICSM students vs. all non-UICSM algebra students

A more extensive analysis of the data on Inglewood 8th and 9th grade students was carried out, using covariance techniques to apply statistical controls. The junior high school group (8th grade) contained 128 UICSM students (E) and 38 Algebra I students (C). The text used by these non-UICSM students was Algebra One, Hayden and Finon (1961). Covariance adjustments were made for the control variables SCAT-V, SCAT-Q, CAA, STEP-Math, sex, and teacher

rating as made by the principals of the schools.[3] An unrestricted linear hypothesis model (using separate group regression weights) was used instead of the standard covariance analysis.[4] Data relevant to the distributions of scores on those tests are given in Table 2.

Table 2. Means and standard deviations of test scores for the UICSM-and non-UICSM groups of 8th grade students.

	UICSM		Non-UICSM	
	Mean	S. D.	Mean	S. D.
SCAT-V	282.30	7.78	282.55	8.81
SCAT-Q	296.22	8.19	297.39	6.94
CAA	64.73	11.35	64.87	8.67
STEP-Math	279.22	7.96	280.68	6.19
	$N_E = 128$		$N_C = 38$	

The criterion variables were the Coop Algebra Test (1950) and the Coop Math, Algebra I, Test (1962). The UICSM group mean scores exceeded the corresponding mean scores of the non-UICSM group, and the differences were statistically significant after covariance adjustments were made, if teacher rating was excluded, as is shown in Table 4.

The senior high school group contained 38 UICSM students (E) and 171 non-UICSM students (C). The control variables, for which covariance adjustments were made, include STEP-Math, CTMM-L, CTMM-NL, sex, and a teacher rating made by school principals. Means and standard deviations of scores on the control variables are given in Table 3.

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3 SCAT: Cooperative School and College Ability Tests (1955) (Q, quantitative; V, verbal) published by the educational Testing Service.

CAA: California Algebra Aptitude Test (1958) published by the American Guidance Service, Inc.

4 We are indebted to Dr. Frank Watson, now at the Cancer Research Hospital, Columbia, Missouri, for making available to us his then unpublished computer program for carrying out the test.

Table 3. Means and standard deviations of scores of UICSM-and non-UICSM 9th grade students on the control tests.

	UICSM		Non-UICSM	
	Mean	S. D.	Mean	S. D.
STEP-Math	284.92	9.46	280.15	9.06
CTMM-L	46.03	7.42	40.96	8.32
CTMM-NL	33.37	5.13	30.80	5.27
	N_E = 38		N_C = 171	

The criterion variables were Coop Algebra Test (1950) and the Coop Math, Algebra I, Test (1962). Again the means of the scores for the UICSM students exceeded the corresponding means of the control group; but after covariance adjustments for all of the control variables, the differences were not statistically significant. However, when covariance adjustment for teacher rating was omitted, the adjusted difference in mean scores on the Coop algebra test was 10.2 and was statistically significant at the 5% level. The results are recorded in the summary table below. It is interesting that the significant differences occurred when covariance adjustments were not made on teacher rating. This suggests that the superior performance of UICSM students may be due to their having superior teachers. Thus, either due to the self-selection factor (superior teachers wanting to teach UICSM) or to their having profited from the UICSM Summer Institute training (or both), it seems that UICSM teachers do get a higher rating by principals, and that their superiority as teachers has a positive effect on student performance.

Table 4. Summary of Inglewood Results

I Junior High

E = UICSM (N = 128)

C = Algebra 1 (N = 38)

Criterion Variable	Group Means E	C	Significance at 5% level when covariance adjustments were made on: All control vars.*	All but teacher rating
Coop. Algebra	22.4	19.9	Not signif.	Signif.
Coop. Math	25.4	23.5	Not signif.	Signif.

*Control variables: SCAT-V, SCAT-Q
CAA, STEP-Math
Sex, Teacher Rating

II Senior High

E = UICSM (N = 38)

C = Traditional (N = 171)

Criterion Variable	Group Means E	C	Significance at 5% level when covariance adjustments were made on: All control vars.*	All but teacher rating
Coop. Algebra	34.5	24.5	Not signif.	Signif.
Coop. Math	30.0	25.8	Not signif.	Not signif.

*Control variables: STEP Math
CTMM-L, CTMM-NL
Sex, Teacher Rating

In order to permit some comparison of the students in Inglewood schools with students in the older pilot and participating schools, a summary of data on the Coop Algebra examination for students who began study of UICSM Course I in 1958 and 1959 is included (Table 5). A detailed discussion related to these data has been given by Tatsuoka and Easley (1963).

Table 5. Coop Algebra means and standard deviations of raw scores for some groups of students in UICSM Course I and comparison groups in 1958 and 1959.

Dates of Testing	UICSM Means	S. D.*	N	Non-UICSM Means	S. D.*	N
May 1959	28.58	8	118	22.35	12	515
Sept.-Dec. 1959	26.72	9	270	20.75	11	161
May 1960	22.70	12	574			
Oct.-Nov. 1960	27.91	9	382			
Jan. 1961	26.18	10	135			
May 1960-Mar. 1961	28.89	11	226			

*Approximations of standard deviations of raw scores from standard deviations of scaled scores.

It may be noted that the Inglewood Senior High UICSM students had a higher mean score on the Coop Algebra examination than the students in these comparison groups.

* * *

Comparison of item difficulty indices for UICSM and non-UICSM students in Inglewood, California

A third comparison of UICSM and non-UICSM students at Inglewood was made with respect to relative success on individual items on the Coop Algegra and Coop Math tests. The percentage of students correctly answering each item of the two criterion tests was computed. Such percentages are customarily called difficulty indices. The smaller the index, the greater is the difficulty of the item, i.e., the smaller the number of students answering the item correctly. The calculations were based on answers by 209 UICSM students and 249 non-UICSM students on the Coop Algebra test, and 187 UICSM and 249 non-UICSM students on the Coop Math test.

Some differences in success for the various test items were noted. Those items for which differences in difficulty indices for the experimental and control groups were found to exceed or equal 0.20 (a significant difference at the 5% level) are listed below.

A. Diff. Ind. $_E$ — Diff. Ind. $_C \geq 0.20$ (The percentage of UICSM students correctly answering an item exceeded, by 20 or more, the percentage of non-UICSM students who got the item right.)

1. Coop Algebra Test

UICSM students did better on items 31, 35, and 37 on Part I and items 10, 11, and 16 on Part II of the Cooperative Algebra test, Form T (1950), published by the Educational Testing Service. The first group of these items deals with combining and simplifying algebraic fractions and the second group deals with the general concept of defining a new quantity as the quotient of two other quantities, e.g., speed as the ratio of distance and time, trigonometric functions defined as ratios of particular sides of a triangle, and cost per article when given the cost of many articles.

2. Coop Math Test

UICSM students did significantly better on items 4, 27, 29, and 38 of The Cooperative Mathematics Test, Algebra I, Form A (1962) which is also published by ETS. The four items listed above treat knowledge of algebraic fractions, non-divisibility by zero, inequalities, and recognizing that a given linear equation has no solution. These are all topics on which UICSM materials place greater stress than conventional texts do.

B. Diff. Ind. $_C$ — Diff. Ind. $_E \geq 0.20$

1. Coop Algebra Test

The comparison group did better than UICSM students on items 9 and 16 of Part I of the test. These items deal with the laws of exponents and graphical solutions of linear equations. (As of the time of testing, the UICSM students had not studied the laws of exponents or two-dimensional graphs of solution sets.)

2. Coop Math Test

Items 7 and 9 of this test were answered better by non-UICSM students. These items test understanding of the definition of coefficient and the laws of exponents. Again these topics had not been studied by UICSM students at the time of testing.

* * *

A principal-axis factor analysis is presently being carried on in an attempt to classify items into several groups which seem to depend on different skills and knowledges. However, no conclusions have been reached at this point. Item analysis is also being carried on in connection with a UICSM elementary algebra inventory which covers many objectives not covered in the two Coop tests.

References: 1. Beberman, M., Vaughan, H. E., High School Mathematics, Units 1-4, University of Illinois, Press, 1960.

2. Hayden, D., Finen, E. J., Algebra One, Allyn and Bacon, Inc. 1961.

3. Tatsuoka, M. M., Easley, J. A., "Comparison of UICSM vs. "traditional" algebra classes on Coop Algebra test scores" UICSM Research Report No. 1, September, 1963.